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SMALL CONCRETE CONSTRUCTION ON THE FARM

THE PURPOSE of this bulletin is to describe sound methods of building a few simple concrete structures useful on the farm. It is assumed that the reader is already familiar with the selection of suitable materials and proper methods of mixing and placing concrete. This subject has been treated in Farmers' Bulletin No. 1279, "Plain Concrete for Farm Use," which should be obtained by those not familiar with it. The rules given in that bulletin should be observed, because care in the selection and use of materials is essential to the success of any concrete construction.

By following the rules outlined in the above-mentioned bulletin and the directions given in this bulletin, any farmer should be able to build the small structures described so that they will be relatively permanent and also add to the appearance and value of his farm.

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SMALL CONCRETE CONSTRUCTION ON THE FARM

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CONTENTS

PREPARATION OF SITE, MATERIALS, AND METHODS

IN THE CONSTRUCTION of walks, feeding floors, basement and barn floors, and similar pavements, the concrete is spread in layers on the ground. Forms for such work are very simple and sometimes may be dispensed with. These structures are therefore easy to build and a satisfactory job is insured if a few directions, especially with regard to drainage and jointing, are observed.

PREPARATION OF SITE

The ground should be cleared of all tree roots and vegetation and graded to the proper depth over the full area of the pavement. Soft, spongy spots should be rammed firm and any consequent depressions filled. Fills necessary in grading the site should be made in horizontal layers about 6 inches thick and thoroughly rammed or otherwise compacted to avoid settlement after the concrete is placed. The depth of excavation is dependent upon the climate and the nature of the soil. Where the ground is soft or subject to the action of frost the excavation should be from 10 to 12 inches deep; where no frost occurs and the soil is porous and not likely to become soft or water-soaked a sub-base is unnecessary, and the excavation may be made equal to the depth of the slab. If a sub-base or cushion is required it should be rammed to a firm, unyielding surface, and if sand or cinders are used they should be thoroughly wetted when being compacted.

DRAINAGE

All walks and feeding floors should preferably be located where the soil drainage is good; but if this is impracticable a porous sub-base or cushion of cinders, sand, or fine gravel must be provided to prevent

the heaving caused by frost action and unequal settlement when the ground is wet. When a sub-base is placed on stiff clay soils, drainage outlets should be installed to carry off any water which might collect and cause injury by freezing.

FORMS

Usually 2-inch lumber of a width equal to the thickness of the concrete slab is used for forms, although 1-inch lumber will serve if it is well staked and braced to prevent bulging.

The forms are usually set after the cushion has been placed and are held to line with their upper edges conforming to the finished grade by stakes driven on the outside.

TYPES OF WALKS AND FLOORS

A pavement may be laid in either one or two courses. The two-course type is built with a thick base of concrete and a thin top coat of rich mortar and is used chiefly for walks or where a smooth finish is desired; the one-course type has but one layer of concrete of a fairly rich mixture and is considered the better type to use where a rough surface is required, as on feeding floors and pavements intended to support heavy loads and resist wear. There is a possibility of separation of the top and base of the two-course type when subjected to heavy loads.

THICKNESS OF SLABS

No concrete slab, especially if exposed to outdoor conditions, should be less than 4 inches thick. Floors of poultry houses and basements of dwellings in well-drained locations are sometimes made 3 inches thick, but a slab of uniform thickness is difficult to get and unless the concrete is full 3 inches thick the floor is likely to prove unsatisfactory.

The concrete should be 5 inches thick where stock is to be provided for and 6 inches or more where traffic is heavy or the ground is insecure. In two-course work the bases of 4 and 5 inch slabs should be 3¼ and 4¼ inches, respectively. The top coat should never be less than three-fourths inch thick, and sometimes, where subjected to heavy loads, it is made 1½ inches.

BLOCKING OFF

A walk or feeding floor should be laid in blocks so that cracks due to settlement or temperature changes will appear in straight, well-defined, rather than irregular, lines. Another advantage is that the blocks can be reset if dislodged by settlement or more easily replaced if badly broken. For good appearance they should be nearly square.

For farm conditions blocks having an area greater than 100 square feet or either dimension longer than 10 feet usually are not desirable. If longer blocks are used they should be made at least an inch thicker than previously recommended.

Where the range in temperature is not very great and there is no danger of frost action, as in the case of interior floors, the concrete is sometimes laid as one sheet without blocking. However, it is advisable to divide the floor into blocks, not larger than 10 feet square, because the difficulty of forming a true surface increases with the size.

The foregoing recommendations regarding blocking off do not apply to road construction, since the conditions under which road paving is laid permit large areas of concrete to be handled expeditiously.

The separation into blocks can be accomplished in different ways. The first step is to lay 2-inch scantlings to grade along two sides of a number of blocks, the width of a block apart. Marks should be made on these side forms, where the joints or divisions are to be made, to facilitate setting the transverse forms and so that the grooves in the top coat of a two-course pavement can be made exactly over the joints in the base.

The base concrete may be laid in a convenient length and the blocks formed by cutting entirely through the base with a trowel or cleaver at the joint lines. The cut should be filled with sand and the top coat applied and grooved directly over the sand-filled joint. Blocks also may be formed by placing a thin beveled strip of wood, or other material, across the width of the walk at each joint and casting several blocks of the base at one pouring. After the concrete has become somewhat firm the strips should be removed and the joints filled with sand before the top coat is applied. The most satisfactory method of forming blocks is to cast them alternately This is done conveniently by placing 2-inch scantling between the side forms at the joint marks so as to form alternate spaces equal to the area of the block. After these alternate spaces are filled with concrete and it has become firm the cross-pieces are removed and the intermediate spaces filled. It is advisable to separate the blocks with tar paper, prepared strips of fiber mastic, bitumen, or sand.

EXPANSION JOINTS

Expansion joints should be located at buildings, trees, curbs, both ends of curves, around manholes, and 40 feet apart in straight runs of walks. These joints are made by leaving spaces from one-fourth to one-half inch wide and in depth equal to the thickness of the slab. They should be filled with suitable compressible material, that will not become soft or run in warm weather. Several thicknesses of tar paper or special preparations composed chiefly of tar are used ordinarily.

MATERIALS

Only good Portland cement of a reliable brand should be used. The sand and stone should be free of foreign matter and should be well graded in regard to size. The course aggregate for the base should vary in size from one-fourth to 1½ inches, but should not be larger than 1 inch for one-course construction. Coarseness and ability to resist abrasion are two essential qualities of the fine aggregate, especially for the top coat. It should be free from particles of earth or other material that might weaken the concrete or cause pit holes. Sand of which 40 per cent is composed of ⅛ to ¼-inch grains is not too coarse.

MIXTURES

In two-course work, concrete for the base is mixed generally in the proportions of 1:2½:5, though 1:3:6 will give good results when

first-class materials are used. The mortar for the top coat is usually mixed 1:2. Concrete for one-course pavements is generally a 1:2:4 mixture.

The concrete for one-course work and for the base of two-course work should be mixed to a jellylike consistency. The mortar for the top course or wearing surface of two-course work should be mixed to a stiffness that will require it to be scraped from the bucket or barrow. If it is made too wet several trowelings will be necessary to obtain the final finish, in which case the wearing quality of the concrete is impaired. The materials are measured by volume, and for the top coat should be exact to insure a uniform color.

PLACING THE CONCRETE

Just before the concrete is deposited the cushion or foundation should be wetted down with water. After the concrete is placed, in one-course construction, the aggregate is compacted by tamping until mortar flushes to the surface, which is then leveled off with a straightedge even with the side forms.

In two-course construction the concrete base is lightly rammed and leveled off with a straightedged board notched over the side forms to the proper depth for the top coat. The mortar top coat is placed as soon as a short distance has been laid and is struck off even with the side forms, after which the surface is roughly floated with a plasterer's trowel. If a good bond is to be expected, it is imperative that the top coat be placed before the base has set. The final floating and grooving of the top coat is not done until the concrete or mortar has been in place from one to four hours and has partly set.

GROOVING THE TOP COAT

Occasionally the top coat is cut through over the joints in the base and the surface marked off by small grooves. This is not structurally essential, but improves the appearance of the pavement by breaking the monotony of an otherwise undecorated surface. After the top coat has been placed, the location for the grooves is determined by the marks previously made on the side forms and found exactly by running the point of a small trowel through the top coat and into the base joint. The trowel is guided by a straightedge and run across the width until a complete cut is made. The four edges of each block are then rounded off with a groover or edging tool. Marks or rough places are erased and the surface given a final finish with a wood float.

A slippery pavement is always undesirable, especially where stock is kept. A rough surface resembling corduroy in appearance offers good foothold and can be easily produced in varying degrees of roughness by sliding a straightedge along the side forms with a sawlike motion and at the same time jigging it up and down a little. This should be done while the concrete is fairly soft. A very satisfactory finish for feeding floors is obtained by roughening the surface with a stiff broom after the concrete has set sufficiently, all the liquid having disappeared. Sometimes foothold for animals is provided on smooth surfaces by making parallel grooves one-fourth to one-half inch deep and about 6 inches apart in two directions with a groover.

A finish of a gritty or sandlike texture that is smooth but not slippery may be obtained by sprinkling a little sharp sand over the surface and lightly rubbing it in with a wooden float used with a circular motion. A glassy surface is produced with a steel trowel after the concrete has set fairly hard. Experience is necessary in determining the exact time for final troweling and in obtaining the various effects produced by the different methods of finishing.

Too much troweling of the surface or troweling too soon after depositing of the concrete not only makes the surface slippery, but also brings an excess of fine material to the surface. This affects the wearing quality of the pavement and is likely to cause "hair" cracks which, although not detrimental, yet mar the appearance of the surface. These cracks may also be the result of too much fine sand.

CURING

Newly placed concrete should be protected with a moist covering of sand, straw, sawdust, canvas, or other material as soon as practicable without marring the surface. The covering should be kept moist for a week and foot traffic should be kept off of the pavement for from 5 to 10 days; animals and heavy loads should not be allowed on the paving for about a month after the concrete has been placed. Paving that has not hardened sufficiently to resist pitting may be protected from rain with a 1-inch layer of sand.

It is not advisable to lay outside pavements in freezing weather,[1] but if unavoidable the materials should be heated and the concrete carefully protected. Manure should never be used to cover newly laid work because it contains acids which react on the green concrete.

DUSTING

Disintegration of the surface of concrete indoor pavements into fine particles is known as dusting and invariably is the result of poor workmanship or materials or both. Some of the causes of dusting are: Too fine and soft a sand; too lean a mixture; insufficient mixing; improper consistency; overtroweling when finishing or using dry cement to hasten the drying of the surface.

There are various treatments designed to harden the concrete and to eliminate "dusting." These may be divided into proprietary and home treatments. Recent preliminary tests by the Bureau of Standards, United States Department of Commerce, have indicated that very good results can be obtained by such treatments.

Two home treatments that have proven very successful and are inexpensive to apply are given below:

SODIUM SILICATE TREATMENT

Commercial sodium silicate (water glass) usually varies in strength from 30 to 40 per cent solution. It is very viscous and has to be thinned with water before it will penetrate the floor. Ordinarily it will be found satisfactory to dilute each gallon of the silicate with 4 gallons of water. The resulting 5 gallons may be ex-

[1] See pp. 21 to 23 of Farmers' Bulletin No. 1279.

pected to cover 1,000 square feet of floor surface one coat. As the porosity of concrete floors varies greatly, the above is only an approximate value which may be used for estimating purposes. The solution should be made up immediately before it is used.

Before the solution is applied the floor surface should be cleaned of all grease spots, dirt, and other foreign matter and thoroughly washed with clear water. To insure the greatest penetration the floor should be thoroughly dry, especially at the first application; if practicable it is well to allow it to dry for several days after the first scrubbing. The solution may be applied with a mop or hair broom and should be brushed back and forth over the surface for several minutes to obtain an even penetration. An interval of 24 hours should be allowed for the treatment to harden, after which the surface should be scrubbed with clear water and allowed to dry. Three applications will usually suffice, but if the floor does not then appear to be saturated a fourth will be required.

ALUMINIUM SULPHATE TREATMENT

A solution of aluminium sulphate should be made in a wooden barrel or stoneware vessel. The quantity required may be estimated on the basis of 1 gallon of solution to each 100 square feet of area. For each gallon of water, 2½ pounds of powdered sulphate will be required. The water should be acidulated by adding 2 cubic centimeters (about ⅖ teaspoon) of commercial sulphuric acid for each gallon. The sulphate does not dissolve readily and has to be stirred occasionally for a period of a few days until the solution is complete.

The floor should be cleaned of grease and dirt and then thoroughly scrubbed. When the surface is entirely dry, a portion of the sulphate solution may be diluted with twice its volume of water and applied with a mop or hair broom. After 24 hours another portion of the original solution, diluted with an equal volume of water, should be applied in the same manner as the first. After another interval of 24 hours there should be a third application, using 2 parts of the sulphate solution to 1 part of water. At each application the liquid should be brushed back and forth over the surface for several minutes to obtain a uniform penetration. After the third application has dried the surface should be scrubbed with hot water.

REPAIRS TO WALKS AND FLOORS

Repairs to concrete pavements usually consists of replacing broken parts, patching holes or worn spots, regrading shallow sinks caused by settlement, cutting out humps caused by expansion, resurfacing to improve foothold, and changing slopes to shed water. If, as in patching holes or regrading shallow sinks, a thin coat of only 1 or 2 inches thickness is necessary, it should be composed of 1:2 mortar. If a greater thickness is required, the mixture should be 1:2:3, the coarse aggregate being of a size equal to about ½ the depth of the depression, but not in excess of 1 inch. The old concrete should be trimmed away until sound material is reached, or at least deep enough to allow for 1 inch of new concrete. The edges of the adjacent good concrete should be kept nearly vertical. The old concrete

should be soaked with water, the excess water being removed, and then given a coat of grout, a mixture of cement and water having a consistency of cream. While this is still moist, the new concrete should be placed and rammed. After standing for from 5 to 20 minutes the patch should be rammed again to minimize later shrinkage. The surface should be worked with a wooden float so as to conform to the surrounding concrete, special care being taken to produce a good finish at the edges of the patch. The new concrete should be covered and kept moist for several days. A pavement that has worn smooth can be roughened by picking the surface with a sharp tool.

Paving that has been cut to permit of work involving the removal of earth beneath it should not be replaced until the back fill has been thoroughly settled and rammed.

ESTIMATING QUANTITIES OF MATERIALS

Pavements are usually measured by the superficial square foot of a certain thickness. Table 1 is useful when estimating the quantity of materials required for slabs. The method of use is illustrated in the following:

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TABLE 1.—*Quantities of materials for 100 square feet of concrete pavement*

Slab thickness	Top coat						Base												
	1:1 mix		1:1½ mix		1:2 mix		1:1½:3 mix			1:2:4 mix			1:2½:5 mix			1:3:6 mix			
	Cement	Sand	Cement	Sand	Cement	Sand	Cement	Sand	Gravel or stone	Cement	Sand	Gravel or stone	Cement	Sand	Gravel or stone	Cement	Sand	Gravel or stone	
Inches	*Bags*	*Cu. yd.*	*Bags*	*Cu. yd.*	*Bags*	*Cu. yd.*	*Bags*	*Cu. yd.*	*Cu. yd.*	*Bags*	*Cu. yd.*	*Cu. yd.*	*Bags*	*Cu. yd.*	*Cu. yd.*	*Bags*	*Cu. yd.*	*Cu. yd.*	
½	3.2	0.12	2.5	0.14	2.1	0.15	1.29	0.07	0.14	1.02	0.08	0.15	0.84	0.08	0.13	0.72	0.08	0.16	
¾	4.9	.19	3.9	.22	3.2	.24	1.94	.11	.22	1.53	.11	.23	1.26	.12	.20	1.08	.12	.24	
1	6.6	.24	5.3	.30	4.4	.32	2.6	.14	.29	2.1	.15	.30	1.67	.16	.26	1.43	.16	.32	
1¼	8.4	.31	6.6	.37	5.5	.41	3.2	.18	.36	2.6	.18	.37	2.09	.20	.32	1.79	.20	.40	
1½	10.1	.37	8.0	.44	6.6	.50	3.9	.21	.43	3.1	.23	.45	2.50	.24	.39	2.15	.24	.48	
2	13.3	.50	10.5	.58	8.7	.65	5.2	.28	.58	4.1	.31	.60	3.34	.32	.56	2.86	.32	.64	
2½							6.5	.35	.72	5.1	.39	.75	4.2	.40	.79	3.6	.41	.81	
3							7.8	.43	.86	6.2	.46	.91	5.0	.47	.94	4.3	.48	.96	
3½							9.1	.50	1.00	7.2	.54	1.06	5.8	.54	1.08	4.9	.55	1.10	
4							10.4	.57	1.15	8.2	.61	1.21	6.7	.62	1.24	5.7	.64	1.28	
4½							11.7	.64	1.29	9.2	.69	1.36	7.6	.70	1.41	6.5	.72	1.44	
5							13.0	.71	1.44	10.3	.76	1.51	8.5	.79	1.58	7.3	.80	1.60	

Example:—How much material will be needed in laying a pavement 20 feet wide and 36 feet long if the 4-inch base is made of 1:3:6 concrete and the ¾-inch top coat is 1:2 mortar?

Referring to Table 1, column of 1:3:6 mixtures and on line with the 4-inch thickness it is found that 5.7 bags of cement, 0.64 cubic yard of sand and 1.28 cubic yards of gravel will be needed for each 100 square feet of the 4-inch base; likewise, from the column of 1:2 mixtures on line with the ¾-inch thickness, it is found that 3.2 bags of cement and 0.24 cubic yard of sand are required for 100 square feet of top coat.

Then for each 100 square feet of pavement 8.9 bags of cement, 0.88 cubic yard of sand and 1.28 cubic yards of gravel will be required; as there are 720 square feet in the pavement the required quantity of material is found by multiplying each of the above quantities by 7.2 making 64.08 bags of cement, 6.43 cubic yards of sand, and 9.22 cubic yards of gravel.

FEEDING FLOORS

A feeding floor should be located convenient to feed and water supplies and should be accessible from pastures, barns or feed lots; the lee of a building, hill, or woods is desirable, as the stock will be protected from cold winter winds. A southern exposure is best, as the heat of the sun prevents ice and snow from remaining for any great period of time.

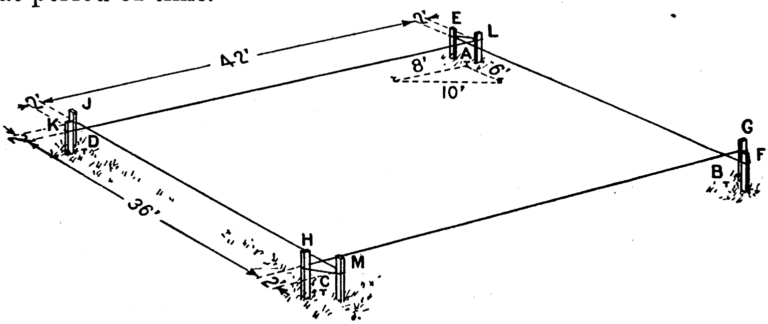

FIG. 1.—Diagram for laying out feeding floor

METHOD OF LAYOUT

The floor should be graded or sloped at least one-eighth inch per foot, one-fourth inch to the foot being more general practice, so to shed water that manure washings may be directed to a manure pit. The following method of establishing the grades of a surface, 36 by 42 feet in area, can be applied in general to all floors whether level or sloping.

Lay out the floor marking each corner with a nail driven into the ground and using the method shown by dotted lines at *A*, in Figure 1, to obtain square corners. To preserve the lines, stretch a string over the nails *A* and *B*, and drive stakes at *E* and *F* with one face of each to line and exactly 2 feet beyond the corners of the floor. In like manner locate and drive stakes *G* and *H*, *M* and *J*, *K* and *L*. These stakes must be driven solidly into the ground and should extend 12 to 15 inches above it. On one of the stakes, located on the highest ground, as *E*, cut a notch 5 inches above ground level. By means of a straightedge or tight chalk line, together with a carpenter's level, establish on *F* a point level with the grade notch on *E*. Since the floor is to have a slope of one-eighth inch per foot and the distance between *E* and *F* is 2+36+2 or 40 feet, cut the grade notch on *F* 40 eighths or 5 inches below the level mark. From the grade notch on *F* run a level line to *M* and, as the distance is 42 feet, make the grade notch 42 eighths or 5¼ inches below the level line. Next, with the line and level establish a grade on *J* 5¼ inches lower than the grade

mark on *E*. Beginning at the grade notch on *E* stretch the chalk-line to the grade notch on *F*, around *F* to *G*, around *G* to *H*, around *H* to the grade notch on *M*, from *M* over the line *GH* to the grade notch on *J*, around *J* to *K*, and around *K* to *L*. Raise or lower the line *KL* until it barely touches the lines *EF* and *JM* over the points *D* and *A*. In like manner adjust the line *HG* with reference to the points *C* and *B*. The adjusted lines show the grade of the top of the finished floor.

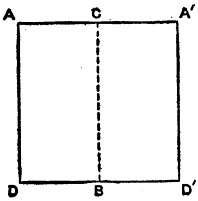

FIG. 2.—Diagram showing floor with center gutter

Feeding floors often are drained along the center line. The slope may be established by the method just described, one half of the floor being laid out first and the other half made to correspond. The point *C*, Figure 2, is the lowest, and *BC* is the center line forming a gutter. The section *ACBD* should be laid out first, the points *A′* and *D′* being made the same height as *A* and *D* respectively.

CONSTRUCTION OF FEEDING FLOORS

The top soil should be removed and the whole site excavated to a depth depending upon conditions described on page 1. If the soil is water-retentive, a cushion will be necessary. As the floor should be formed of blocks, it will be best to start at the lowest point, so that rain will not run from hard on to newly placed concrete, and set forms for a strip 6 feet wide and 36 feet long, which permits of six blocks 6 feet square being cast with one setting of forms. The forms should be arranged as in Figure 3.

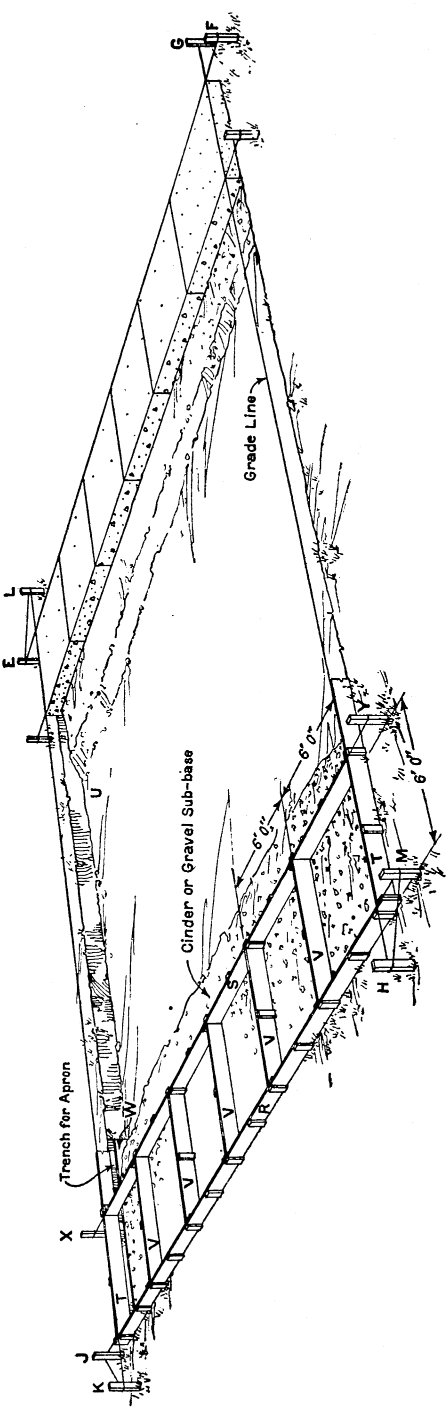

FIG. 3.—Layout of forms for feeding floor

Forms for two or more alternate strips may be laid out at one time, depending upon the quantity of concrete to be placed in a day. Stakes should be driven at *X* and *Y*, Figure 3, so that a line, when stretched between them, will be 6 feet from the line *JM* and will just touch the lines *KL* and *HG*. The scantlings, *R* and *S*, should be set along the lines *JM* and *XY* so that their inside upper edges just touch the lines. Transverse scantlings (*T*) set with the inside upper edge immediately under the lines *HG* and *KL* will form the ends of the strip of floor. The 36 feet between these end forms should be divided into six equal spaces. Additional transverse scantlings (*V*), 6 feet long, should be set so that alternate areas 6 feet square are formed. The concrete should be mixed, placed, and cared for as previously described. When the first blocks have hardened sufficiently to be self-sustaining, the transverse scantlings may

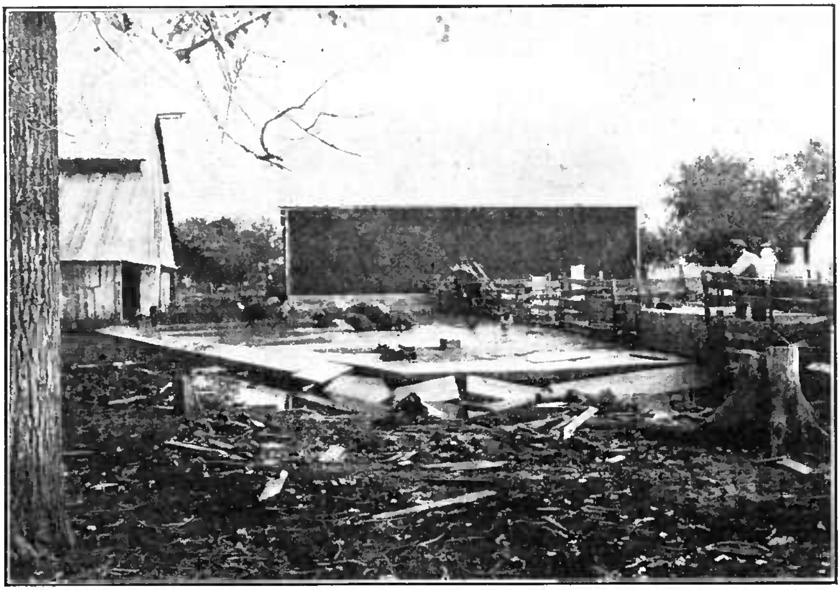

FIG. 4.—Failure of feeding floor without apron

be removed and the intermediate spaces concreted. The same operation should be repeated for each strip. Marks made on the lengthwise forms when the first strip of floor is laid out will facilitate placing the forms for the remainder of the floor.

DETAILS OF FEEDING FLOORS

Frequently, because of the topography or to save excavation, the concrete slab of a feeding floor is laid above the grade of the surrounding ground, and when this is done an apron or curtain wall should be built under the sides of the floor. An apron is advisable under all feeding floors to prevent undermining by hogs, (fig. 4), and to eliminate harborage for rats and raveling due to wash.

The apron should be about 6 inches thick and extend to below the frost line, 18 inches below the ground being usually sufficient except

in very cold climates. The trenches for the curb may be dug after the forms are set and filled at the same time the slab is poured. If a cushion is required, the edges may be beveled back to prevent the material falling into the trench as shown at *U*, Figure 3, or a temporary board form *W* may be used.

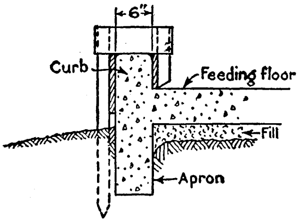

FIG. 5.—Curb and apron

Generally, feeding floors are 5 inches thick and of the one-course type. The concrete should be at least a 1:2:4 mixture, the surface being finished by floating as described on page 4. The area, of course, will depend upon the number and size of troughs to be provided and the kind and number of stock to be fed. Usually 15 square feet is provided for each hog and 40 square feet for each head of cattle.

Gutters should be provided around the sides of the floor and probably are best formed by building a curb 4 to 6 inches high above the grade of the floor; the curbing also serves to retain feed upon the floor. Forms for such a curb, which may be cast separately or with an apron, are shown in Figure 5.

Consideration should be given to the exact location of drinking troughs, feed racks, fence posts, and other equipment, so that

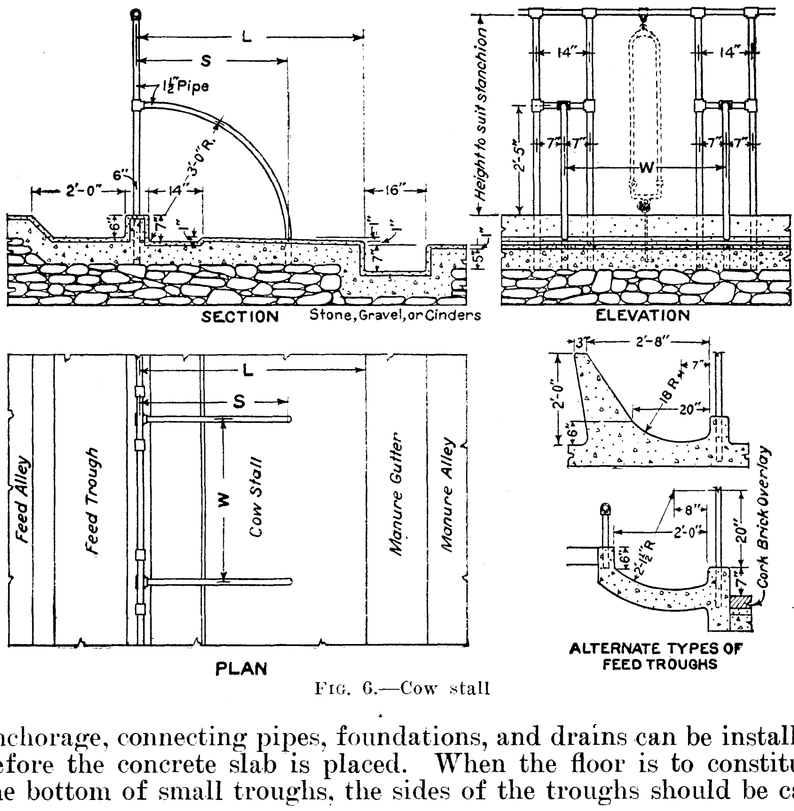

FIG. 6.—Cow stall

anchorage, connecting pipes, foundations, and drains can be installed before the concrete slab is placed. When the floor is to constitute the bottom of small troughs, the sides of the troughs should be cast

at the same time as the floor or before it has set too hard. The trough form should be set in place and leveled as soon as the concrete floor is laid. As the floor is sloped the top of the trough will be higher at one end or side than at the other, depending upon its position, unless the bottom of the form is made to conform to the grade of the floor. Foundations for large tanks should be placed before the floor is laid. Anchorage for racks may consist of dowels or straps set half their length in the floor and to which the rack standards may be secured. Post holes for removable fences may be formed by inserting sleeves of pipe or wood plugs with a diameter a trifle larger than that of the posts.

BARN FLOORS

The concrete for barn floors should be mixed and handled as in the construction of walks and feeding floors. There should be a cushion of nonporous material under the entire floor if the soil is water-retentive. A cushion is advisable directly under all concrete stall floors in order to break capillary attraction and to secure a measure of insulation. A semirough or float finish is desirable, as it will not become slippery. Figure 6 shows details of a typical cow stall[2] the dimensions of which, for several breeds, are given in Table 2.

TABLE 2.—*Suggested dimensions for cow stalls* [1]

Breed	Width (W)				Length (L)					
					Small		Medium		Large	
	Ft.	*In.*	*Ft.*	*In.*	*Ft.*	*In.*	*Ft.*	*In.*	*Ft.*	*In.*
Holstein	3	6 to	4	0	4	10	5	2	5	8
Shorthorn	3	6 to	4	0	4	8	5	0	5	6
Ayrshire	3	6 to	3	8	4	6	5	0	5	6
Guernsey	3	4 to	3	6	4	6	4	10	5	4
Jersey	3	4 to	3	6	4	4	4	8	5	0
Heifers	2	9 to	3	2	3	8	3	10	4	2

[1] Dimension *S* (see fig. 6) should be 3 feet 6 inches for cows and 3 feet for heifers and young stock. Stalls for cows in milk should be not less than 3 feet 4 inches wide. In determining the length of stalls the largest and the smallest cows of the herd should be measured. The longest stall should be laid out at one end of the row and the shortest at the other. The gutter should form a straight line between the two, thus providing stalls of various lengths. The horizontal distance between shoulder point and tail head plus 6 inches is approximately the proper length of stall from stanchion line to edge of gutter.

The stanchion curb should be made first, but before the concrete is placed all plumbing fittings, stanchion sleeves, uprights, and anchor bolts should be set accurately in the forms. Figure 7 suggests a convenient arrangement of forms and method of holding the stanchion upright in place until the concrete hardens. The gutter and manger may be formed by means of templates as shown in Figure 8. Figure 9 shows a method better adapted to forming the high-backed manger shown in Figure 6. Templates for use in the latter method may be made of wood, or patented metal templates may be purchased from barn-equipment dealers. After the curb, gutter, and

[2] Farmers' Bulletin 1342, "Dairy Barn Construction," contains information regarding floors and other features of dairy-barn construction. Drawing No. 1416, showing the use of concrete and cork-brick floors in stalls may be had upon request of the Division of Agricultural Engineering, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

manger have been formed, the rest of the paving should offer no difficulty. As cows vary in size, the length of the stalls should be graduated from one end of the row to the other.

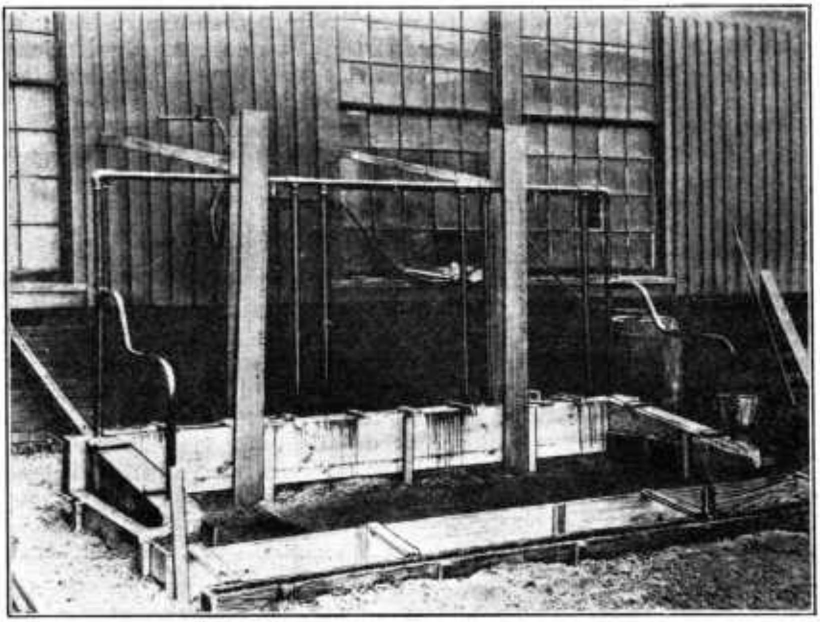

FIG. 7.—Placing curb and stanchion

Figure 10 illustrates a good type of horse stall [3] which presents no structural difficulty.

WALKS, CURBS, AND STEPS

WALKS

A walk is a strip of paving generally 3 or more feet wide and may be laid along the shortest route or follow an easy grade. Water will readily run off if the walk is built a little higher than the surrounding ground and is crowned or made with one side a trifle lower than the other. Figure 11 illustrates the usual method of setting up the forms.

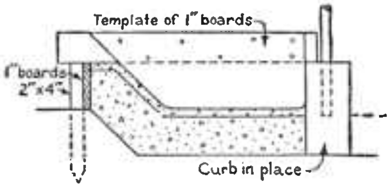

FIG. 8.—Template for forming trough

CURBS

Curbs may be of either two-course or one-course construction, but the tendency now is toward one-course work; that is, the same mixture throughout. A good finish can be obtained by properly tamping and spading the concrete, removing the forms as soon as practicable, and troweling the surface.

[3] Drawing No. 655, showing details of this and two other types of horse-stall floors, may be had upon request of the Bureau of Agricultural Engineering, Department of Agriculture, Washington, D. C.

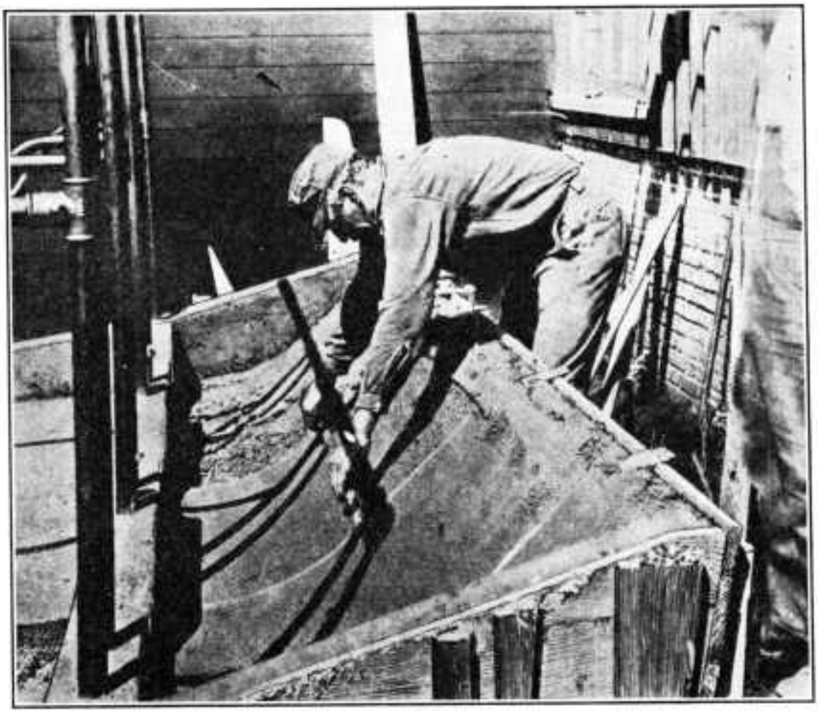

FIG. 9.—Forming trough with templates

The plain curb is usually built 6 to 8 inches thick at the top, 8 to 10 inches thick at the bottom, and 18 to 24 inches deep. Figure 12, *A*, shows how the forms are constructed and braced. Figure 12, *B*, shows the construction of forms for a combined curb and gutter. If the soil requires that a sub-base be provided, gravel or cinders to a thickness of 6 inches may be used. The concrete should be mixed in the proportions of 1:2:4. The curb should be built in sections not over 10 feet in length and expansion joints should be provided 25 feet apart. Plain

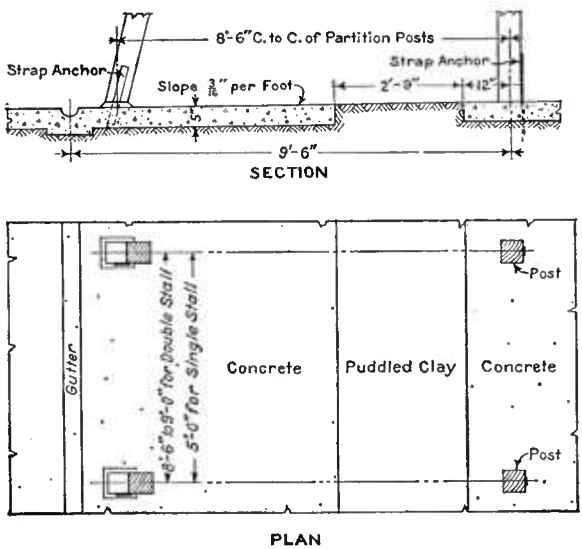

FIG. 10.—Horse stall

curbs may be precast in sections 4 to 8 feet long and are usually 4 to 8 inches thick and 18 to 24 inches high. Each section should be reinforced with one rod one-fourth inch in diameter for each 6 inches in height. The rods should be tied together with wires spaced about 6 to 8 inches apart. A piece of heavy woven-wire fencing 1 inch less

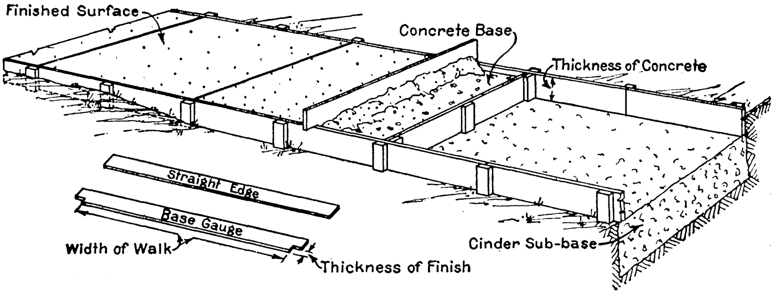

FIG. 11.—Walk forms

in length and height than the section makes satisfactory reinforcement; the wire should not be less than No. 10 gauge.

STEPS

The vertical height or face of a step is called the "riser" and the horizontal surface the "tread." Concrete steps are built by casting the risers and treads on a slab the thickness of which depends upon the span or method of support.

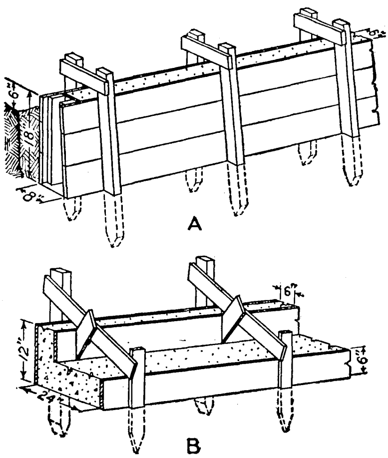

FIG. 12.—A, Plain curb; B, Curb with gutter

When the slab rests on solid earth or on earth fill between concrete or other masonry walls and there are but three or four steps from 3 to 4 feet wide, a 4-inch slab is sufficient; but for wider and longer flights the slab should be 6 inches or more in thickness. Two arrangements of step forms are illustrated in Figure 13. The forms are cut away to show the construction.

Steps that are not built on solid or filled earth must be self-supporting and hence must be reinforced. The reinforcement given in Table 3, for slabs of different lengths, should be placed lengthwise (from top to bottom) and 1 inch up from the underside of the slab. It is advisable to place rods of small diameter extending across the width of the slab, 12 to 24 inches apart and securely wired at the intersections, to the larger rods. It is very important that self-supporting steps have a firm support at the head, such as the slab of a concrete porch or masonry wall; the foot may be secured as in Figure 14.

TABLE 3.—*Reinforcement for step slabs*

Length of slab	Thickness of slab	Longitudinal rods		Transverse rods	
		Diameter	Spacing	Diameter	Spacing
Feet	*Inches*	*Inch*	*Inches*	*Inch*	*Inches*
2–3	4	¼	10	¼	12–18
3–4	4	¼	7	¼	12–18
4–5	5	¼	6	¼	18–24
5–6	5	¼	5½	¼	18–24
6–7	6	¼	5	¼	18–24
7–8	6	⅜	4	¼	18–24
8–9	7	½	5	¼	18–24

The concrete should be mixed in the proportions of 1: 2: 4, but, when a ¾-inch top coating of mortar is to be applied, a 1: 3: 6 mixture is satisfactory for supported slabs. The entire slab should be poured at one time and the concrete should be mixed fairly dry, so that when placed it will not be forced over the riser forms at the bottom of the steps by the pressure from above. The surface of the treads should be finished as soon as the base concrete is placed. A rough sand finish is preferable, as it offers a good foothold. Removal of the forms as soon as the concrete has set sufficiently to resist the imprint of the finger will permit of erasing the form marks by rubbing with a sanded wood block or similar tool.

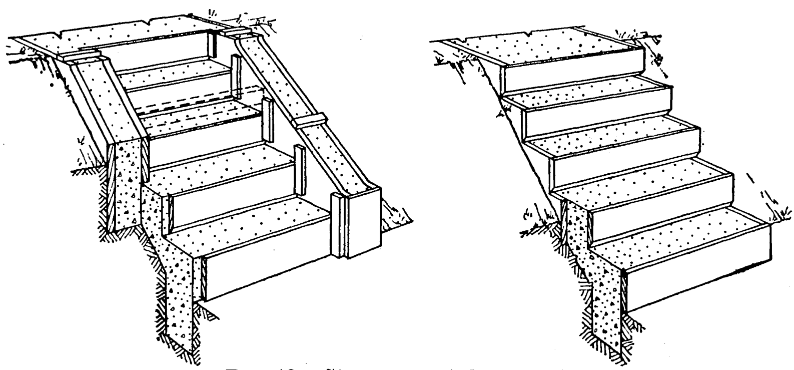

FIG. 13.—Steps supported on earth

The riser should bear a certain relation to the width of the tread and at the same time should be between 6 and 8 inches in height. Low risers and broad treads are generally preferable for outside steps. Risers 6½ to 7 inches high, with properly proportioned treads, permit of ascent with least effort and are common practice. High risers and narrow treads are used only where the horizontal distance is limited. A rule giving a desirable proportion is that twice the height of the riser plus the width of the tread should equal 24. Although not necessary, it is a good plan to project the tread one-half to three-quarter inches beyond the riser. This may be accomplished in the manner shown in Figure 15. The treads should have a pitch of from one thirty-second to one sixteenth inch toward the front in order to shed water.

TANKS AND TROUGHS

Concrete suitable for tanks and troughs should be made of materials well graded as to size, in the proportions of 1: 2: 4 and mixed fairly wet. Special care should be taken to make the concrete resistant to water percolation,[4] when there is any doubt regarding the quality of workmanship or materials, a 1: 2: 3 mixture had best be used. The addition of hydrated lime reduces the permeability of concrete but the quantity should not exceed 10 per cent of the weight of the cement; that is, 9.4 pounds of hydrated lime to each sack of cement. Where hydrated lime is not available, cement may be added to the basic mixture in the same proportions. As leakage is apt to occur at joints, the concrete for the whole structure should be poured continuously, but when this is impracticable care must be taken to bond the adjoining sections.[5]

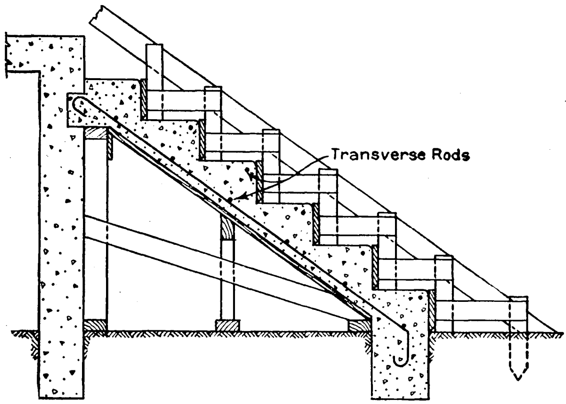

FIG. 14.—Forms for self-supporting steps

As soon as practicable the forms should be removed and the exposed surfaces well brushed with a creamy mixture of cement and water so as to fill the pores. The concrete should be properly cured; that is, kept damp for a week, as too rapid drying will produce cracks.

The inside walls of shallow tanks and troughs, the contents of which may be subject to freezing, should have a slope of about one-half inch per foot of height so that ice will rise and not burst the walls. Large tanks are generally built without this slope, since large quantities of water are not so likely to freeze solid.

Foundations extending below frost line are necessary for water tanks, especially the larger ones, to prevent damage due to settling. Where frost action is likely or the drainage is poor, a porous cushion as described on page 1 should be placed under the tank bottom. The soil under tanks should be all of the same bearing power to permit of uniform settlement; that is, the foundation should not rest partly on rock or an unyielding soil and partly on soft soil.

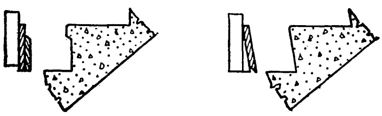

FIG. 15.—Types of risers with corresponding forms

[4] Directions for making water-tight concrete are given in Department of Agriculture Yearbook Separate 824, "Securing a Dry Cellar," and in Farmers' Bulletin 1279, "Plain Concrete for Farm Use."

[5] See page 12, Farmers' Bulletin 1279, "Plain Concrete for Farm Use."

REINFORCEMENT

The reinforcement specified herein for each type of trough and tank should be placed in the position indicated; if a change is made without careful consideration of equivalent values substituted, reinforcement may not serve the purpose and the probable result will be leakage or failure.

Rod reinforcement for floors or bottoms of tanks should be placed in two layers at right angles and 2 inches up from the bottom of the slab. In small tanks these rods may be bent in the form of a U, so as to serve as continuous reinforcement for both bottom and vertical walls; when this requires too long a rod the reinforcement of the bottom should be bent so as to extend up into the wall from 10 to 20 inches (Fig. 16).

Horizontal rods should be placed around the outside of and wired to the vertical rods, and in round tanks the spacings between the horizontal rods should increase gradually from the bottom to the top. The wall reinforcement should be placed about 1 inch from the outer face of rectangular tanks and 2 inches from the face of round above-ground tanks. The reinforcement of below-ground tanks should be placed in the center of the wall section. When

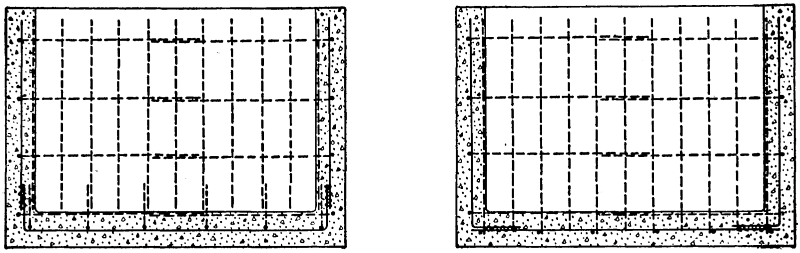

FIG. 16.—Use of L-shaped and U-shaped rods in locating splices

impracticable to obtain rods of sufficient length to extend around the perimeter or girth, shorter rods may be spliced or hooked together, the splices or hooks being located in the middle of the sides and never at the corner of rectangular tanks. For convenience in locating these splices the rods may be bent in the form of a U or an L, depending upon the length of the rods (Fig. 16).

A hook as illustrated in Figure 17, *A*, can be easily made by slipping a pipe over one end of the rod and using it as a lever. A splice is made by lapping the plain ends of the rods 40 diameters and wrapping them securely with wire (Fig. 17, *B*) , baling wire being satisfactory for this purpose. Forty diameters is equal to 10 inches for ¼-inch rods, 15 inches for ⅜-inch rods, 20 inches for ½-inch rods, and 30 inches for ¾-inch rods. Hog fencing of No. 9 or 10 gauge wires is used for reinforcement in the floors of tanks. Poultry wire of 1-inch mesh and 19 gauge or heavier will serve for reinforcing small feeding troughs.

FIXTURES

Water inlet and outlet pipes should be laid before the concrete floor of the tank is poured. The water level can be regulated

by screwing a length of pipe into the outlet to serve as an overflow. All exposed metal pipes and fittings should be galvanized or otherwise rust-proofed.

A pavement around the drinking trough is very desirable, because it prevents the formation of mud holes and protects the foundation of the tank by keeping water away from it. An expansion joint should be made between the tank and paving, so that any settlement or expansion of one will not effect the other.

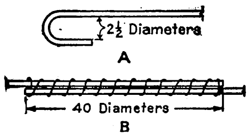

FIG. 17.—Joining reinforcement; A, Hook; B, Splice

SIZE OF TANK

The size of a water tank is determined by the daily consumption, the rate of supply, and the length of time it may be necessary to store water. As a guide, the following daily allowances are suggested: For all household purposes, 40 gallons per person; cow, horse, or mule, 12 gallons; sheep or hog, 1 gallon. A tank should hold sufficient for from 2 to 4 days and more when the pump is operated by a windmill.

Where a large quantity of water is to be stored for a long period of time, tanks are not practicable on account of the cost. Reservoirs or basins are generally used for this purpose.[6]

SMALL FEEDING TROUGHS

Troughs similar to those shown in Figure 18 are convenient for feeding and watering hogs or other small animals. The dimensions may be varied to suit special conditions, but a trough should not be made larger than 2½ feet wide, 5 feet long, and 18 inches high, if it is to be precast, unless additional reinforcement is provided. If cast

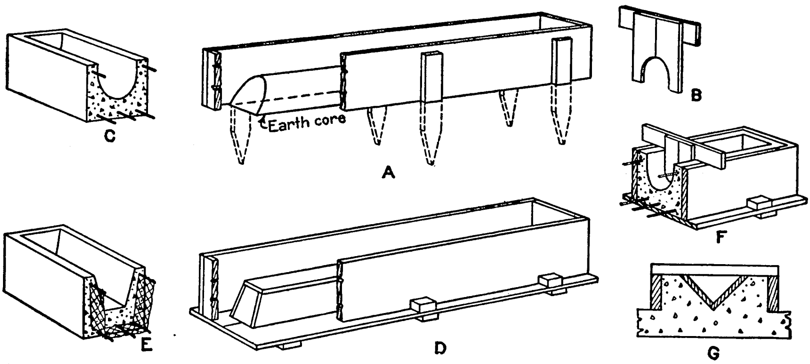

FIG. 18.—Feeding troughs

in place and without reinforcement, a trough may be 10 feet long and as wide as desired, but should not be over 18 inches high; although no reinforcement is necessary a little is desirable to insure against cracks and breakage. Figure 18 illustrates several methods of casting small troughs. *A* shows a form for casting a trough upside down using an earth core. The core is built, approximately to shape, of plastic earth; the bottomless box is then secured in place

[6] Department of Agriculture, Farmers' Bulletin 828, "Farm Reservoirs."

with stakes and the core worked to exact shape with a template *B*, using the form as a guide. *C* is a section of the completed trough. The use of a wooden core and pallet, on which the trough may be cast and carried to the place where it is to be used, is illustrated in *D*, and *E* is a section of the finished work. A third method is shown at *F*. After the forms for the trough are set the concrete is poured, worked into place with a trowel, and shaped with a template. A mortar topping or surface coat is then placed and troweled to a smooth surface. Sometimes the sides and ends of a trough are cast directly on a concrete floor which forms the bottom of the trough as in *G*. In such case the sides should be built before the concrete floor hardens, or they may be poured when the concrete of the floor is placed.

WATERING TROUGHS

An oblong tank is preferable in that it permits more stock to be watered at one time than does a square tank of the same area. When water is plentiful shallow troughs set on piers (Figure 19) may be

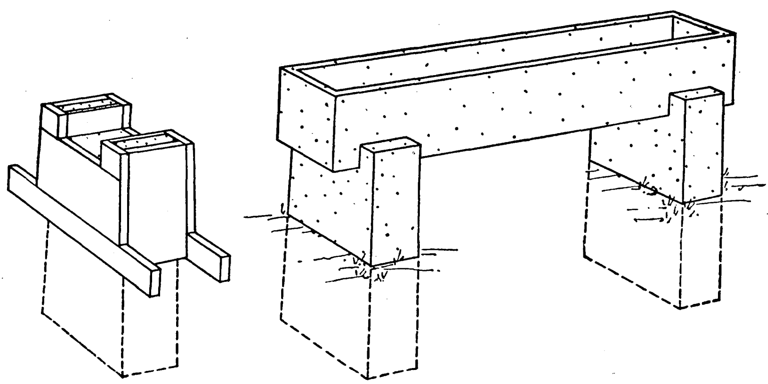

FIG. 19.—Small drinking trough on piers, and pier form

more desirable, as they require less concrete. The height of the piers will depend upon local conditions and they should be spaced not more than 6 feet apart unless extra reinforcement is used.

The larger rectangular drinking troughs vary from 2 to 3 feet in width, and the length is determined by the number and kind of stock to be watered at one time. The depth varies from 1 foot to 2 feet 6 inches. As these troughs are relatively small and built directly upon the ground, they do not require very much reinforcement. Heavy woven wire is sometimes used, but ¼-inch round rods, spaced 6 inches apart in both directions, are better, since the wire mesh is difficult to place accurately.

Since it is always desirable to pour the troughs as a unit to avoid construction joints, the most convenient arrangement of forms and reinforcement should be decided upon before starting work on the site.

Delay in pouring can be minimized if the forms are arranged as panels which can be quickly assembled and the reinforcement, if not too heavy, is bent and wired together ready for placing. If the pouring of the concrete can not be completed in one day, the bottom

can be poured and allowed to harden before the walls are placed, provided due precaution is taken to procure a water-tight joint between the floor and walls, as suggested in Figure 20.

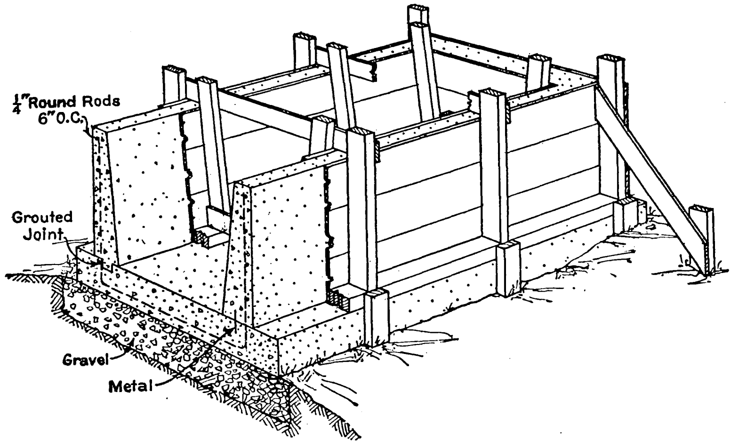

FIG. 20.—Method of constructing rectangular trough on cushion. Watertight joints made with 6-inch strip of galvanized metal or grouted tongue and groove

Figure 20 illustrates a convenient arrangement of forms for a trough requiring no footings but with a cushion under it; Figure 21 shows the arrangement of forms where footings are required. In such case the footing trenches should be dug and the outside form

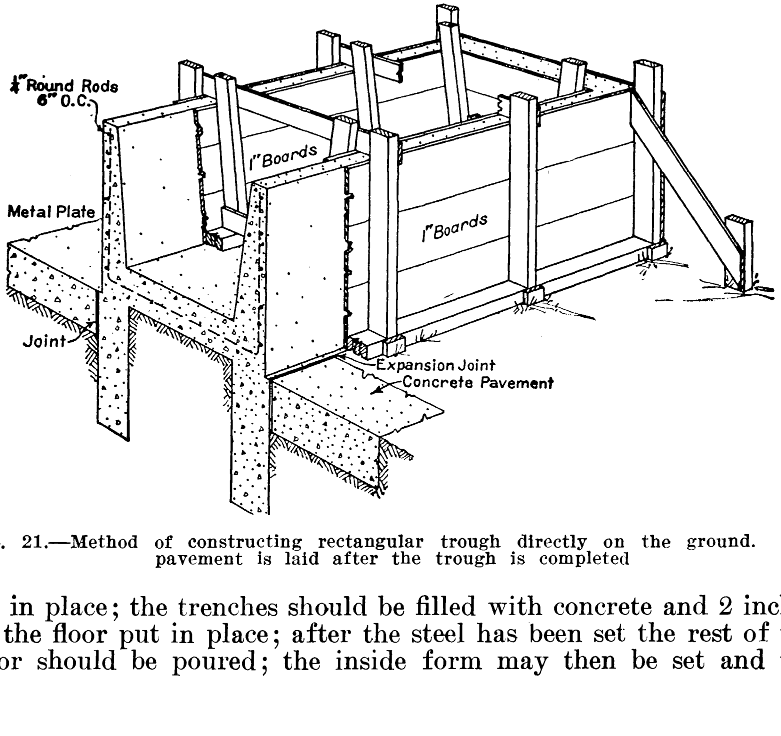

FIG. 21.—Method of constructing rectangular trough directly on the ground. The pavement is laid after the trough is completed

set in place; the trenches should be filled with concrete and 2 inches of the floor put in place; after the steel has been set the rest of the floor should be poured; the inside form may then be set and the

walls completed. Forms for round troughs are somewhat more difficult to make.[7]

WATER STORAGE TANKS

A method of building rectangular forms for tanks is illustrated in Figure 22. The posts or studs of the inside form are tapered 4 inches at the bottom and are permitted to extend into the floor slab.

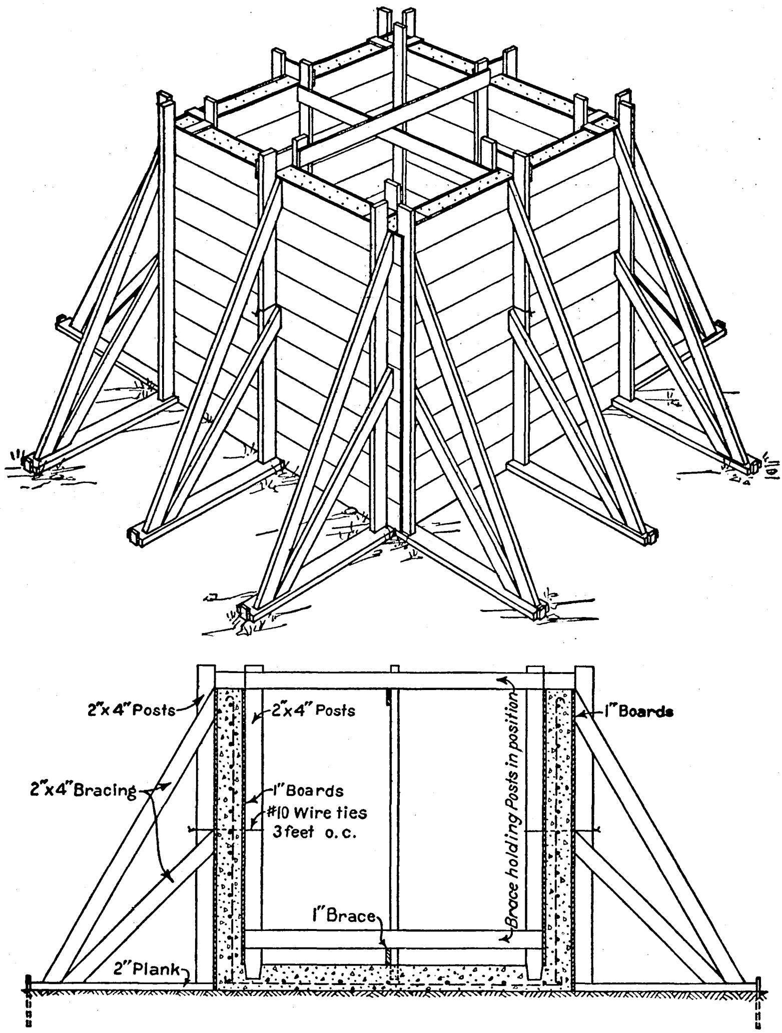

FIG. 22.—Form for large tank

They can be supported 2 inches or more from the ground by placing bricks or stones under the ends. The taper permits the studs to be withdrawn easily after the concrete floor has hardened. When the studs are removed the holes formed by them should be filled with

[7] The construction of such a form for a trough 6 to 8 feet in diameter is shown in Figure 3 of Farmers' Bulletin 1279.

1:2 mortar. The vertical wall rods should be hooked under the floor reinforcement as shown and held in position temporarily by nails driven under the top hook and into the side form or else by running a horizontal rod under the top hooks, securing it by wires to cleats supported on top of the forms.

In Table 4 is given the reinforcement, thickness of concrete, and capacity of tanks of various depths. The area of a rectangular tank does not influence the thickness of walls or amount of reinforcement as much as does the depth of the water, therefore the data of the table may be used for tanks of almost any area. However, it is advisable to limit the length of the longest side to 20 feet, especially in tanks over 4 feet deep, since if special provision is not made, expansion or contraction cracks may occur in the walls.

TABLE 4.—*Reinforcement for rectangular or square tanks, using smooth round rods*

Depth of tank	Thickness of wall	Diameter of wall rods	Spacing-wall rods		Floor rods [1]		Gallons per square foot area
			Vertical	Horizontal	Thickness of slab	Spacing [1] ⅜-inch rods	
Feet	*Inches*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	
3	5	⅜	5	10	6	10	22½
4	5	⅜	4	8	6	8	30
5	6	⅜	3	6	6	7½	37½
6	7	⅜	2½	5	6	7	45
7	8	½	3	6	6	6½	52½
8	10	½	2½	5	6	6	60
9	11	¾	5	10	8	5	67½
10	12	¾	4	8	8	4	75

[1] The floor rods should be placed in two layers at right angles to each other, each layer being spaced as indicated above. For floor reinforcement of elevated tanks see Table 6.

ROUND TANKS

Tanks of large capacity are generally made circular since less material is required than in rectangular tanks of the same capacity. Table 5 indicates the reinforcement and thickness of concrete required for tanks of different sizes. Circular forms generally are made in bands or cylinders 2½ to 4 feet high and are raised as the work progresses as in silo construction. The forms which are really silo forms may be made one-fourth, one-half, or the full height of the tank, but the supporting rings should not be over 2½ to 3 feet apart and should be closer if the depth of concrete to be poured in one operation is in excess of 3 feet. For farm work a form 3 feet high is advisable, as there is less likelihood of the forms bursting, because of a too great depth of wet concrete, and as the concrete can be spaded more easily and with greater assurance of voids being eliminated. Moreover the mixing and placing of the quantity of concrete required to fill a form of this depth and from 10 to 16 feet in diameter constitutes an average day's work. A 30-inch form is preferable when the diameter of the tank is much greater than 16 feet.

TABLE 5.—*Reinforcement for circular tanks using smooth round rods* [1]

Inside diameter of tank	Depth of tank	Thickness of walls and floors	Approximate capacity	Rods in wall				
				Horizontal			Vertical	
				Diameter	Spacing		Diameter	Spacing
					Bottom	Top		
Feet	*Feet*	*Inches*	*Gallons*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*
6	3	6	630	¼	12	15	¼	36
6	4	6	840	¼	10	15	¼	36
6	6	6	1, 260	¼	7	15	¼	36
8	3	6	1, 120	¼	10	15	¼	36
8	4	6	1, 500	¼	8	15	¼	36
8	6	6	2, 250	¼	5½	15	¼	36
8	8	6	3, 000	¼	4	15	¼	36
10	3	6	1, 760	¼	9	15	¼	36
10	4	6	2, 350	¼	6½	15	¼	36
10	6	6	3, 520	¼	4	15	⅜	36
10	8	8	4, 700	⅜	7	15	⅜	30
10	10	8	5, 870	⅜	6	15	⅜	30
12	4	6	3, 380	¼	5	15	¼	36
12	6	6	5, 070	¼	3	15	¼	36
12	8	6	6, 760	⅜	7	15	⅜	30
12	10	8	8, 450	½	7½	15	⅜	30
12	12	10	10, 150	½	6	20	⅜	30
14	4	6	4, 600	¼	4	15	⅜	36
14	6	6	6, 900	⅜	4	15	⅜	36
14	8	6	9, 210	½	7½	15	⅜	30
14	10	8	11, 510	½	7	15	⅜	30
14	12	10	13, 810	½	5½	20	⅜	30
14	14	12	16, 120	½	5	20	⅜	30
16	4	6	6, 010	⅜	4	15	⅜	36
18	4	6	7, 610	½	6	15	½	36
20	4	6	9, 400	½	5½	15	½	36

1 Floors, which should rest on firm soil, may be reinforced with rods as in column 5 spaced as in column 7 for each of two layers; run layers in opposite directions. For elevated tank floors see Table 6. In smaller tanks 4-inch concrete floors reinforced with woven wire are sufficient.

ELEVATED TANKS

Frequently, round tanks are set on top of concrete or masonry silos or well houses, thus putting the water under a head or pressure and at the same time eliminating the cost of an extra tower. The walls and footings of the structure upon which the tank is to be erected must be sufficiently strong to take the load of the tank when filled. Tanks deeper than 10 feet and of a diameter greater than 14 feet should not be elevated except under expert supervision. Most homemade monolithic concrete silos are strong enough to support such a load, but to be on the safe side the opinion of a designer or other competent person should be had.

The inlet and outlet pipes and the overflow of a tank erected upon a silo should run up one corner of the chute, far enough from the wall to permit of a covering of insulation to protect them from freezing. There should be an emergency overflow pipe through the wall, about 6 inches below the cornice and projecting a few inches.

It is necessary to bridge across the top of a continuous doorway of a silo supporting a tank. The top of the doorway frame should be 12 inches below the bottom of the tank floor. A precast lintel or beam (Fig. 23), which has seasoned for at least 28 days, should be put in with one face flush with the inside of the wall, the concrete of the walls being poured with the lintel in place. The use of a precast lintel obviates the necessity of a special form.

A platform should be provided to support the concrete floor of the tank until it has set hard enough to sustain its own weight. Such support may be made of 2-inch planks on 2 by 10 inch joists securely braced and supported. The 2 by 10 inch joists may be supported on top of the inside form, which should be lowered 12 inches below the bottom of the slab to allow for the depth of the joists and 2-inch planks. Another method is to use studs for posts extending from the floor of the silo, cross-braced and capped; the 2 by 10 inch joists rest on the cap.

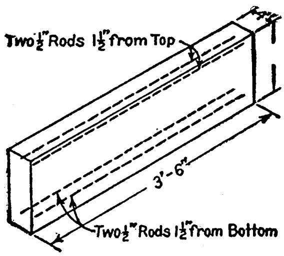

FIG. 23.—Reinforced lintel

Unless the tank is unusually large the walls may be of the same thickness as the silo walls, generally 6 inches, but reinforced as provided for in columns 5 to 9 of Table 5. The floor slab must be heavily reinforced (Table 6). The floor rods should be placed in two layers, the bottom layer being supported on pebbles 1 inch above the platform. The rods of the top layer should be at right angles to those of the bottom layer and tied to them every 12 inches with baling wire. The rods in the middle third of the floor should be spaced closer than those of the outside thirds, as indicated in columns 5 and 6, Table 6, and Figure 24. Alternate rods should be of sufficient length to permit of the ends being bent back into the floor, 1 inch below its top surface, a distance of ¼ the diameter of the tank and pointing to the center. The remaining rods should be bent straight up, extending vertically 2 feet into the tank wall. The whole floor must be poured continuously. If the platform is covered with waterproof paper, the planks can be more easily removed and leakage of the liquid mortar of the concrete through cracks in the platform is prevented. After the floor has seasoned the forms for the tank may be set.

TABLE 6.—*Floor reinforcement for elevated circular tanks* [1]

Diameter	Height of tank	Thickness of floor	Diameter of rods	Spacing of rods in center third	Spacing of rods in outside thirds
Feet	*Feet*	*Inches*	*Inch*	*Inches*	*Inches*
8	4-10	6	½	5	8
10	6	6	½	5	8
10	8	7	½	4	6
10	10	7	½	4	6
12	6	7	½	4	6
12	8	8	½	3½	5
12	10	9	½	3	5
14	6	8	½	3½	5
14	8	9	½	3	5
14	10	12	½	3	5

[1] This table provides for 2 layers of rods; the bottom layer to be placed 1 inch above the bottom of the slab and the second layer immediately above the first layer and at right angles to it. The table can be used for rectangular tanks, but it is important that 2 layers of steel be used, the rods in each layer to be spaced as indicated in column 5, that is, the space between the rods can not be increased in the outside thirds. The span is the longer dimension and corresponds to the diameter of circular tanks.

COVERS FOR CONCRETE TANKS AND SILOS

A silo roof is generally pitched so as to afford head room when the silo is filled (fig. 25) but a tank roof or cover is usually made flat or

with very little slope. In all roofs and covers a manhole about 2 feet square should be provided to permit access to the tank or silo. The opening may be protected with the battened wood cover, or, if the roof has considerable pitch, a dormer framed upon the concrete slab and covered with metal lath and stucco. The roof is generally built with an overhang or eave to divert the roof water from the walls. The overhang may be eight-sided or round; likewise the roof may be formed into eight surfaces, forming a pyramid, or it may be round, forming a cone.

The eave form or box is made of 2-inch lumber from 6 to 10 inches wide, the wider boards being used for the larger structures, to which a 1 by 6 inch board or metal strip is attached (fig. 26). This box may be supported on brackets bolted to the outside form, if it is of metal, the brackets being set before the last foot of the concrete wall is poured. If the outside form is to be of wood and a round eave is desired, the box may be made by cutting a circular form for the bottom of the box and nailing the 1 by 6 to it. The eave or overhang should be reinforced with a ½-inch hoop rod around which are bent the ends of the wall and roof reinforcement.

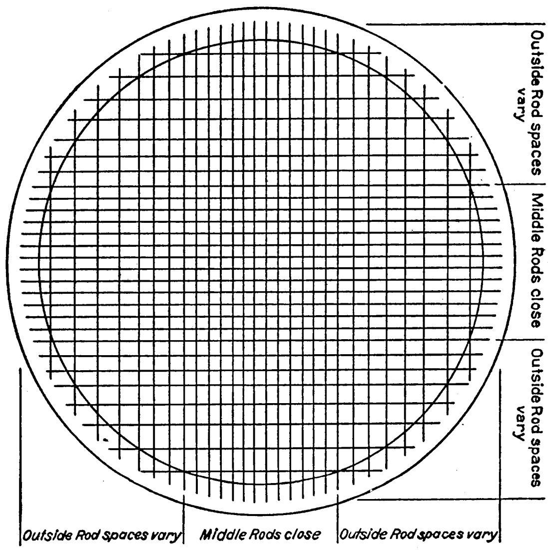

FIG. 24.—Reinforcement for floor of elevated circular tank

The framing of the roof form may consist of 2 by 4 inch supports resting on the top ring of the inside form or recesses (see fig. 27) in the wall. Another good method [8] is to insert tapered 2 by 2½ inch wood blocks in the concrete wall 7 or 8 inches down from the top of the wall. These blocks are driven out after the form is removed and ½ by 2 by 12 inch irons put in their place (fig. 28) and wedged up to support the roof and eave form. Still another method of supporting the form rafters is the hook shown in Figure 29. The form for a tank cover may be supported on a framework built up from the tank floor, since, as a rule, the height is not more than 10 feet.

PITCHED ROOFS

The sheathing on the form rafters can be placed either radially or crosswise and should be covered with building paper to facilitate removal of the forms and to prevent mortar leaking through the joints.

Round rods are used for reinforcement and should be placed radially, so that the ends at the eave are 2 feet apart. (See fig. 27.)

[8] From Nebraska Experiment Station Bulletin 138.

When the tank is of a large diameter, it is not necessary to extend all the radial rods to the peak; therefore alternate rods can be

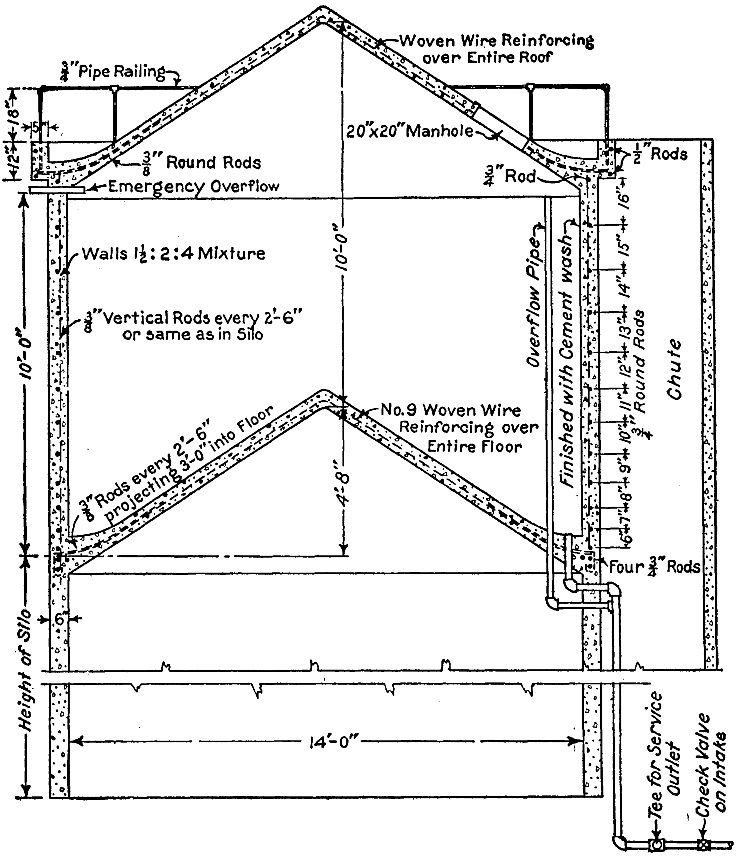

FIG. 25.—Elevated tank with pitched roof and floor

stopped from one-half to two-thirds the distance to the peak. Hoops of 1/4-inch rods should be spaced 18 inches on centers and securely wired to all the radial rods. Extra rods should be used around manholes as shown. There should be 1 inch of concrete below the rods and 3 inches above, thus making a 4-inch slab. The vertical rise of the roof should be as follows: Ten feet diameter, 2 1/2 feet; 12 feet diameter, 3 feet; 14 feet diameter, 3 1/2 feet; and 16 to 22 feet diameter, 4 feet. A trammel (fig. 29) revolving about a pin at the peak and resting on the eave form may be used to bring the concrete to a true surface. The concrete should be mixed 1 : 2 : 4 and as wet as it can be put on without creeping or sliding to the eave. The pouring of the concrete should start at the eave, and it should be placed around the

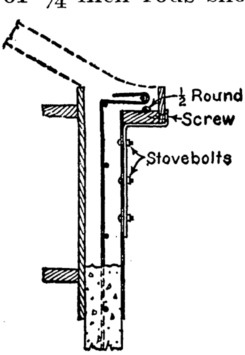

FIG. 26.—Eave form supported on outside wall form

roof in bands, or courses, approximately 2 feet wide. The surface should be troweled smooth and kept from drying out too rapidly.

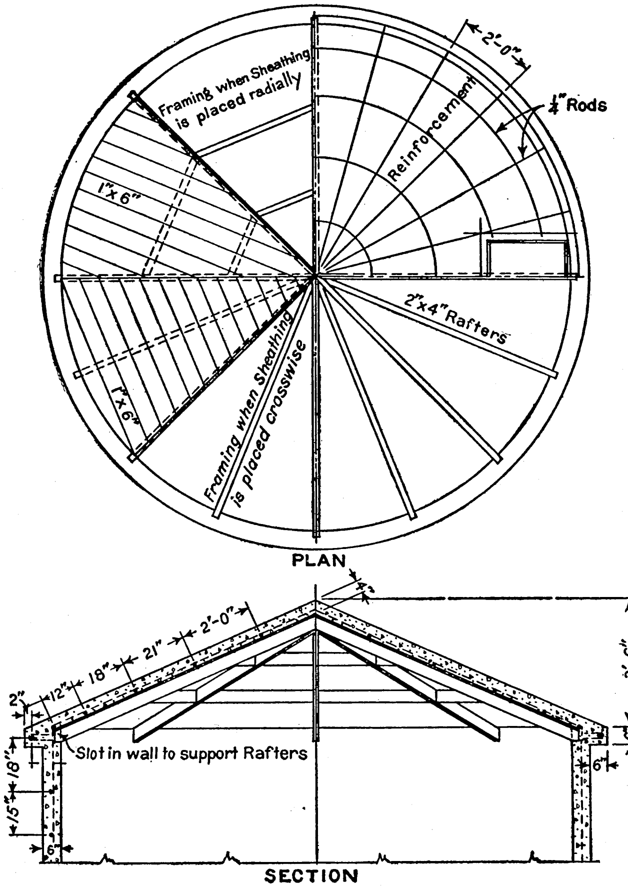

FIG. 27.—Form for pitched roof

FLAT ROOFS

Table 7 indicates the reinforcement and thickness of slab for various roof spans with no superimposed load and with loads equivalent to 1 and 2 feet of earth. Such slabs are not sufficiently strong to permit of driving over them, hence the tanks should be located where this will not occur. When the span is greater than 14 feet, beam and column construction, which is beyond the scope of this bulletin, is recommended. The span of the roof or cover of rectangular tanks refers to the smaller dimension and of round tanks to the diameter. The longitudinal rods should be wired to the transverse rods at least every 12 inches and the wall rods should extend 2 feet above the wall, so that they may be bent down and wired to the reinforcement of the roof slab.

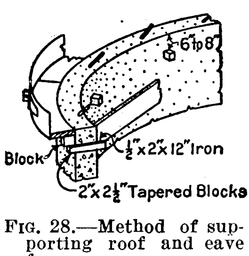

FIG. 28.—Method of supporting roof and eave forms

TABLE 7.—*Reinforcement for flat tank covers* [1]

	No earth fill			1-foot earth fill			2-foot earth fill		
Span	Thickness of slab	Size of rods	Spaced	Thickness of slab	Size of rods	Spaced	Thickness of slab	Size of rods	Spaced
Feet	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*
4	4	½	6	4	½	6	4	½	6
6	4	½	6	4	½	6	4	½	6
8	4	½	6	4½	½	6	6	½	5
10	4½	½	6	6	½	5	7½	½	4
12	5	½	6	7	½	4	-------	-------	-------
14	6	½	5	-------	-------	-------	-------	-------	-------

[1] The rods indicated in this table should be spaced in one layer 1 inch above the bottom of the slab and extending across the shorter dimension (the diameter of circular tanks). One-half inch rods spaced 12 to 18 inches on centers should extend longitudinally on top of the bottom rods and be wired to them. All rods should extend over the walls, and it is advisable to make a hook on both ends of each rod.

UNDERGROUND TANKS

Tanks of the construction indicated in Tables 4 and 5 may be built below the surface of the ground with a roof or cover, as specified in Table 7. If the earth walls of the excavation are self-supporting, only inside forms will be necessary. Unless the soil is soft a cushion under the floor of the tank will not be necessary. As the forms must be removed through the manhole, they should be so designed, as in Figure 30, that they can be easily taken apart.

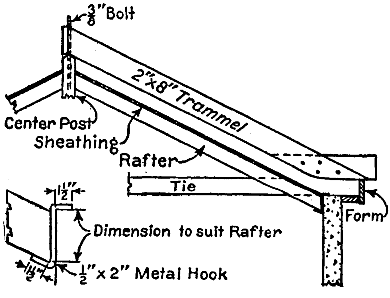

FIG. 29.—Trammel for shaping the concrete of the roof

OTHER USES FOR TANKS

Concrete tanks are suitable for storing many liquids. If the inside surfaces are treated with paraffin, cider and vinegar may be stored in them. Paraffin may be applied cold or hot. In the cold method, the paraffin is dissolved in a volatile carrier like naphtha until a saturated solution is obtained. Four pounds of paraffin dissolved in one-half gallon of gasoline or naphtha will make 1 gallon of solution. This solution is applied like paint to the surface of the concrete, which it penetrates according to the dryness, porosity, and temperature. One gallon will cover about 200 square feet of surface. Good ventilation should be provided in the tank when this solution is being applied and special precaution should be taken to prevent fire or explosion, as naphtha is very inflammable. Paraffin may be applied in melted form. It requires 6½ pounds of solid paraffin to make 1 gallon when melted. One gallon will cover about 250 square feet of surface. The work should be done on a warm day, and the concrete should be warmed with a blowtorch or by other artificial means. The blowtorch is useful in thinning and spreading the layer of paraffin.

Concrete tanks have not proven satisfactory for storage of vegetable oils or strong acids, especially sulphuric acid, unless carefully treated with a coating or lining that is inert to the action of the special substance to be stored.

Figure 31 shows a typical tank used in dairies for cooling cans of milk. The clear width and length should be sufficient to permit the cans to be set side by side and the depth such that the water will

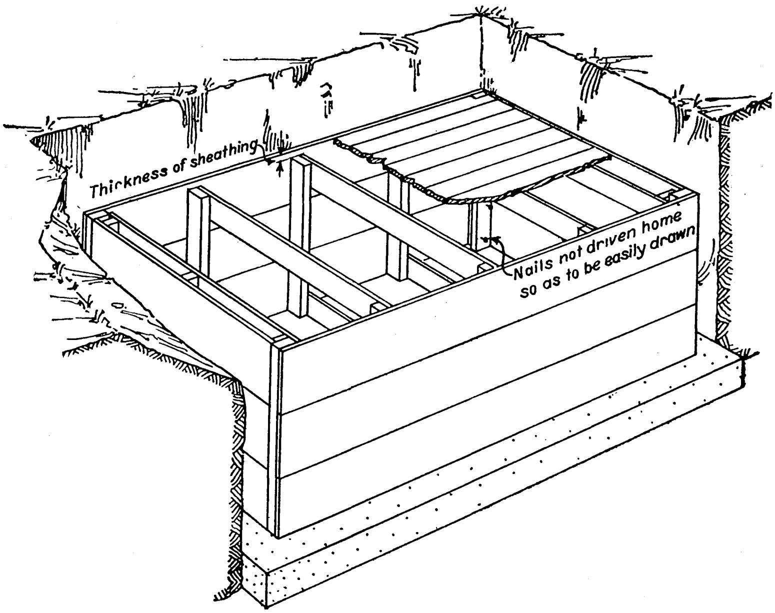

FIG. 30.—Form for tank below ground

cover the neck of the can. The depth of water is regulated by the length of the loosely fitted or threaded pipe stopper and overflow.

HOG WALLOWS

Figures 32 and 33 illustrate two types of hog wallows with sufficient area for sixteen to eighteen 150-pound hogs. As a general guide, 4 to $4\frac{1}{2}$ square feet should be provided for each 100 pounds of hog. The side walls should be carried below grade as an apron to prevent undermining by rooting hogs, and it is well to grade the ground outside the concrete basin so that water slopped over the top will drain away, thus eliminating the possibility of a mud wallow on the outside. A 1 : 3 : 5 concrete will be strong enough, but light rod or woven-wire reinforcement in the floor is advisable.

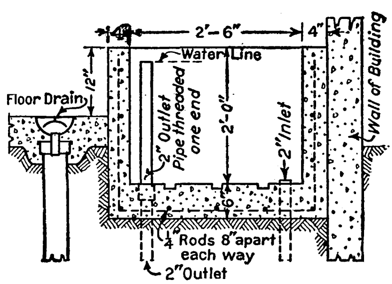

FIG. 31.—Milk cooling tank

MANURE PITS

Manure pits generally are rectangular and shallow, with a sloping bottom built below or partly below the surface of the ground

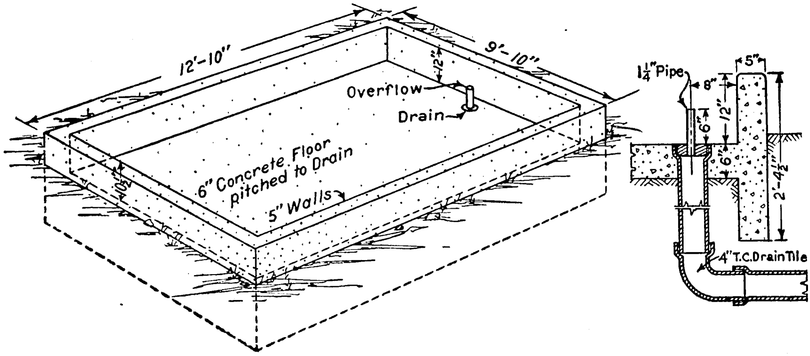

FIG. 32.—Hog wallow

(Fig. 34). The pit should not be more than 5 feet deep at the lower end and should be wide enough to permit of backing a wagon or spreader into it. The slope of the floor should not be more than 1

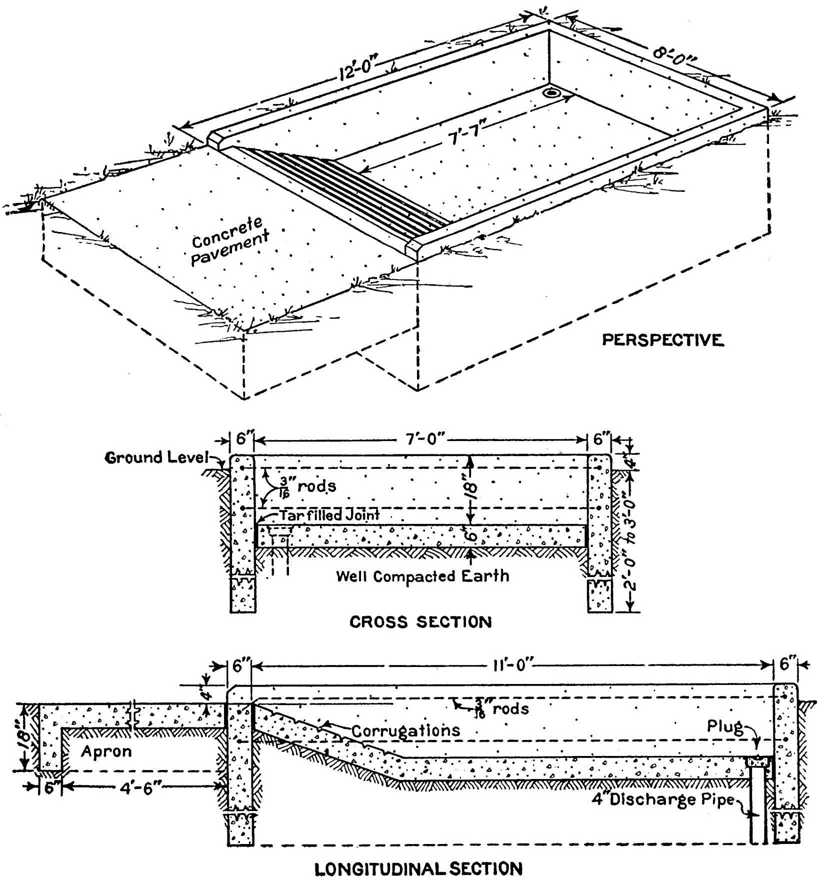

FIG. 33.—Another type of hog wallow

foot in 5 and the surface should be roughened or grooved to provide foothold for horses. A sump should be provided in one corner at the low end of the pit so that the liquid can be collected and pumped back over the manure.

Frequently manure pits are covered [10] with a frame superstructure, which not only affords weather protection but may also support a litter-carrier track and permits screening to keep flies in. Galvanized or copper fly screening should be used.

The size of the pit is dependent upon the number and kind of stock and the storage period. It may be approximated upon the basis of 1½ cubic feet per head of stock (horses or cows) per day if the stock are well bedded.

As the pit should be fairly water-tight, the concrete should be mixed in the proportions of 1:2:4 or 1:3:5 if the aggregate is well graded. As manure pits are generally shallow, the walls below the ground need not be reinforced, but a little reinforcement in the sec-

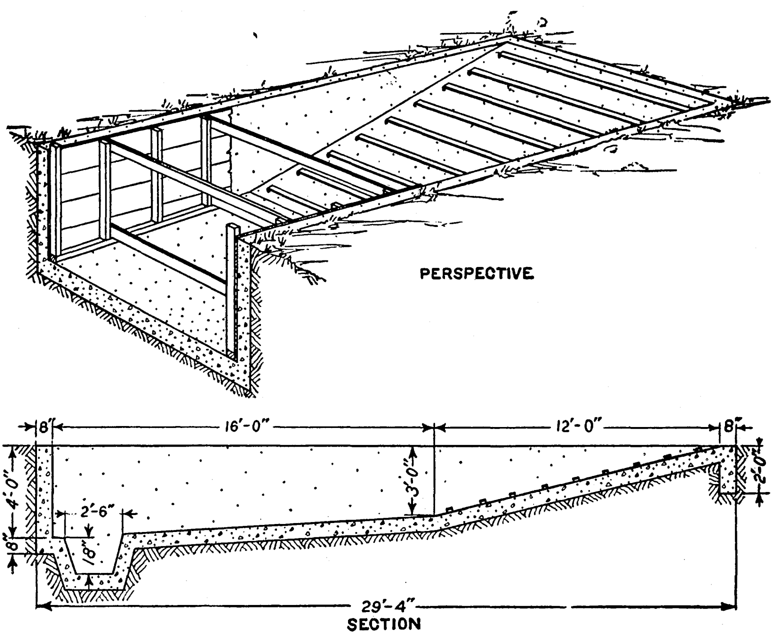

FIG. 34.—Manure pit

tion exposed above the ground is advisable, especially at the corners. The floor should be reinforced, woven-wire fencing being generally sufficient.

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[10] Design No. 1095, a working drawing of a covered manure pit, may be had of the Bureau of Agricultural Engineering, Department of Agriculture, Washington, D. C.

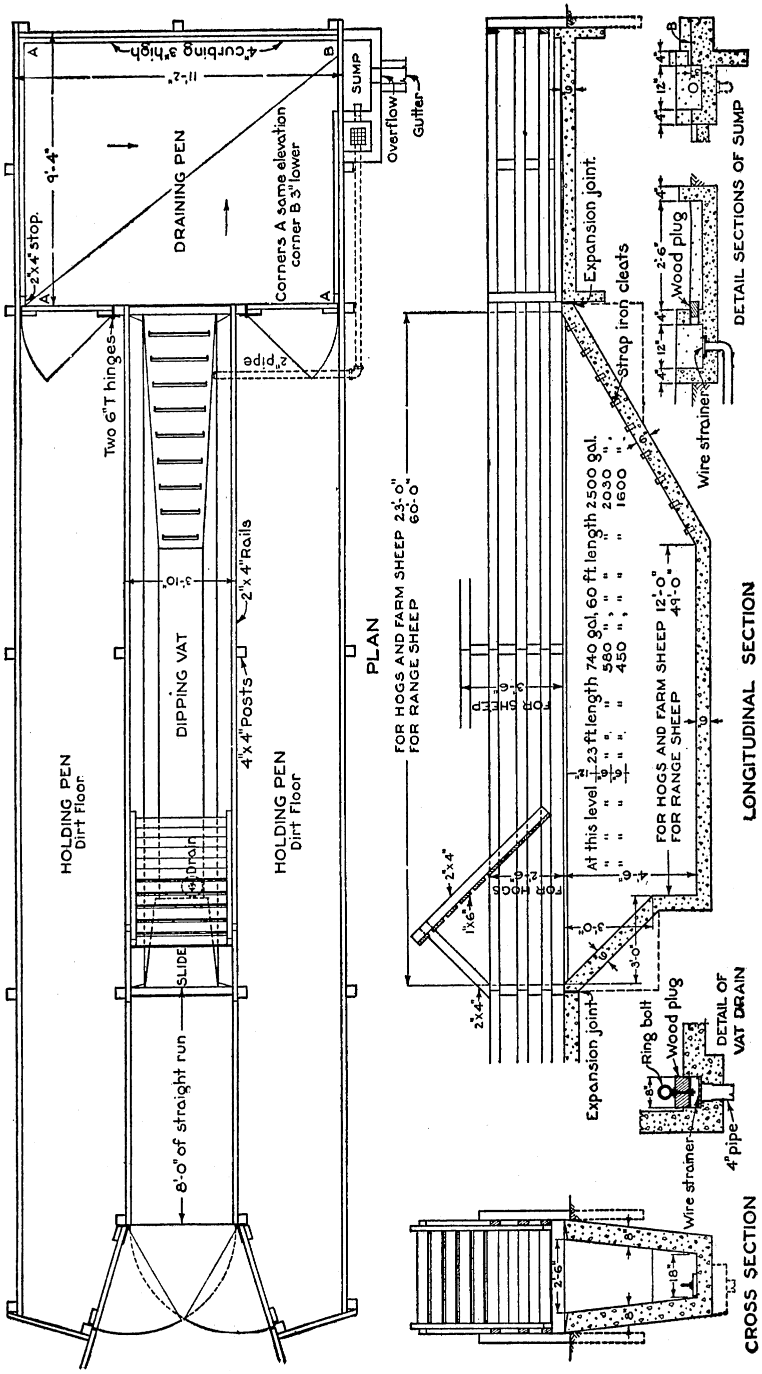

FIG. 35.—Sheep and hog dipping vat

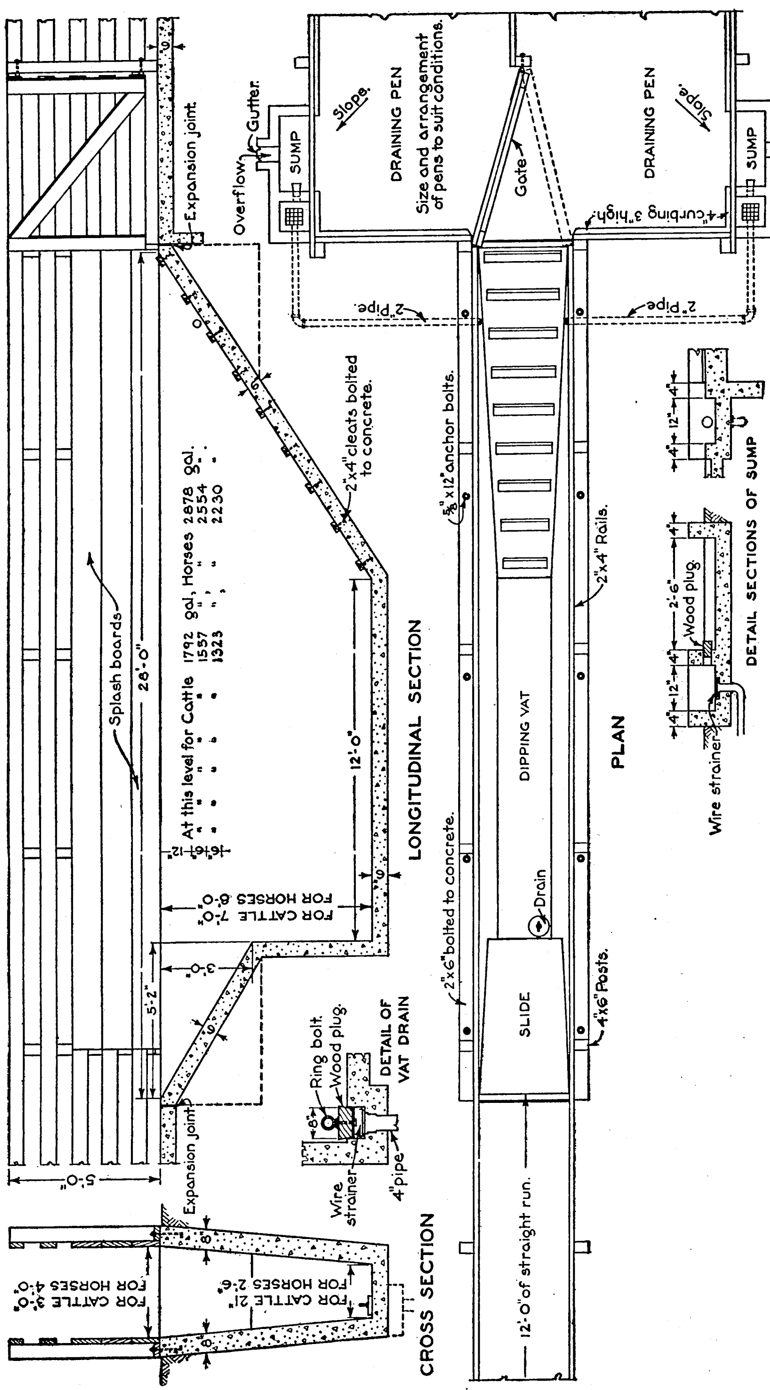

FIG. 36.—Cattle and horse dipping vat

DIPPING VATS

The site of a dipping vat should be well drained, near to a water supply, and convenient for a chute leading from a small, well-fenced lot or corral. The means to be used in heating the dip should be considered in case this is required.

One general shape with modifications as to size is common for horses, cattle, sheep, and hogs. The vat is merely a box with inclined ends by which the animals enter and leave. Figure 35 shows the size of vats and suggested arrangement of inclosures recommended for hogs and sheep, and Figure 36 shows a vat adapted to horses and cattle.

The deep part of the vat should be excavated first, the earth at the ends being then sloped for the slide and climb. The outlet drain pipe should be laid so that the top of the elbow bend will be even with the surface of the finished floor. A sump hole should be provided if a pump is to be used to remove the liquid.

Forms for the side walls and one end will be necessary and may be built of 2 by 4 inch studs with 1 by 6 inch sheathing. If the banks stand firm, inside forms only will be needed. The concrete of the floor may be laid directly on the earth, no porous cushion being required. The concrete floor, end wall, and slopes should be laid first, using concrete of a fairly dry consistency for the sloping ends, so that it will stay in position without the use of forms. After the side forms have been set and securely braced the concrete for the walls, mixed to a mushy consistency, may be poured.

The entrance slope should be troweled very smooth so that the animals may slide into the vat without injury. Occasionally the slide is covered with a smooth steel plate, care being taken to embed the edges in the concrete. Bolts may be set in the soft concrete, clear of the animal's path, to which plates are later secured. Iron cleats, with bent-down ends embedded in the concrete, are sometimes used to aid the animals in climbing out; old wagon tires, cut in lengths not greater than 20 inches and turned down 4 inches at each end, will serve the purpose. To insure good footing, a 1-inch clearance should be left between the flat surface of the cleats and the concrete. The cleats should be spaced 18 to 20 inches apart for horses and cattle and 10 to 12 inches for sheep and hogs.

Draining pens are necessary, the size and arrangement being dependent upon the local conditions. It is best to use concrete posts, as they will require no replacing. The floor should slope to the sumps and the surface should be corrugated or grooved to lessen the danger of slipping. A curb 6 inches high and 4 inches wide should be built around the floor. Two-inch galvanized pipes, placed as shown, drain the dip back into the vat and a plug in one end of the sump permits rain water to be led away from the vat when not in use. The concrete should be allowed to cure or season at least three weeks before use.

WATER HEATER

Figure 37 shows a convenient arrangement for heating water in large quantities. The concrete should be 1:2:4 mix and allowed to season thoroughly. In selecting the aggregate care must be taken to choose material that will not disintegrate under the influence of heat; cinders, broken hard-burnt brick, or tile being excellent materials. Cinder concrete does not weather well and should be protected by a mortar coat of cement and sand at least 1 inch thick. If fire brick can be obtained readily, it will be best to line the fire box with them.

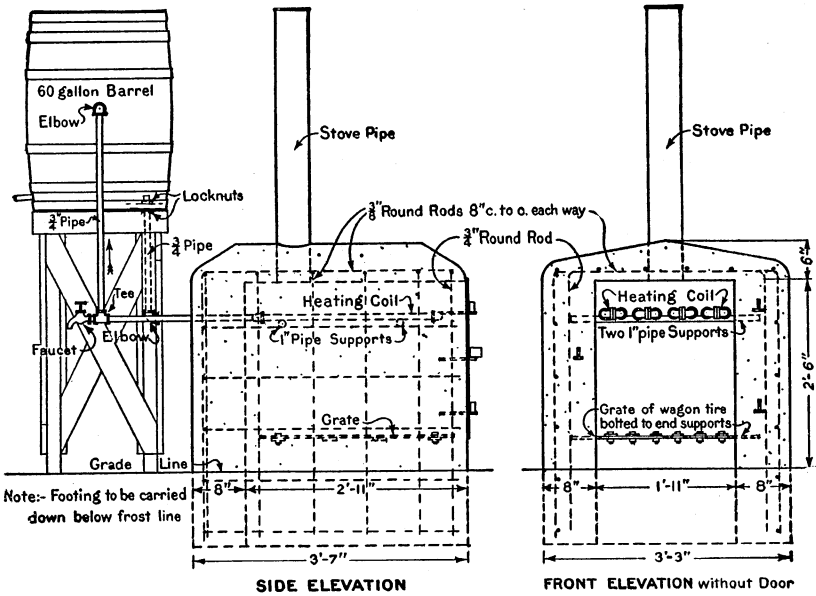

FIG. 37.—Concrete water heater

REFERENCES TO DEPARTMENT OF AGRICULTURE PUBLICATIONS RELATING TO THE STRUCTURAL USE OF CONCRETE

Farmers' Bulletin 825 describes the construction of pit silos.

Farmers' Bulletin 828, Figures 27 and 28, illustrates a method of lining an earth reservoir with concrete. Figure 26 shows the use of a concrete dam, 12 feet high, on a gravelly stream bed.

Farmers' Bulletin 1243 describes the construction of turnouts, check and head gates, and division boxes as used in irrigation.

Farmers' Bulletin 1227 shows the construction of one and two chamber septic tanks, cesspools, grease traps and switch boxes, and privy vaults.

Farmers' Bulletin 1448 illustrates the construction of a tank over a milk house, concrete well lining, cistern and filter.

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